

What is claimed is:

1. A laminated material of a segregating membrane and a segregating membrane supporting material in which the segregating membrane is

5 laminated on the segregating membrane supporting material comprising:

a segregating membrane including at least a choice of polysulfone-based, polyvinylidene fluoride-based, polyamide-based, polyimide-based, or polyacrylonitrile-based high polymer materials, and

a segregating membrane supporting material wherein,

10 fibers are assembled in three-dimensions to form non-woven fabric,

non-woven fabric is processed by thermo-compression to join together fibers, which make up the non-woven fabric in sheet form, making the segregating membrane supporting material, and

non-woven fabric including at least 10 weight %

15 polyacrylonitrile-based synthetic fibers having a fiber length of 1mm-25mm is processed by thermo-compression making a segregating membrane supporting material with overall bulk density 40% to 75% of the density of the fibers which make up the non-woven fabric, and

wherein polyacrylonitrile-based synthetic fibers included in the

20 non-woven fabric of the segregating membrane supporting material are dissoluble in amide-based solvents or in sulfoxide-based solvents as a mutual solvent for forming the segregating membrane.

2. A laminated material of a segregating membrane and a segregating  
25 membrane supporting material as recited in claim 1 wherein the segregating membrane supporting material is made from non-woven fabric, including 10 weight % to 100 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

30 3. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 1 wherein the segregating membrane supporting material is made from non-woven fabric, including 20

weight % to 70 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

4. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 1 wherein the segregating membrane supporting material is made from non-woven fabric, including 30 weight % to 60 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

5. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 1 wherein the segregating membrane supporting material is made from non-woven fabric, including 40 weight % to 60 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

6. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 1 wherein size of polyacrylonitrile-based synthetic fiber included in non-woven fabric of the segregating membrane supporting material is diameter of 3.5 to 49.6  $\mu\text{m}$ .

7. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 1 wherein permeability of the segregating membrane supporting material is  $0.5 \text{ cm}^3/\text{cm}^2/\text{sec}$  to  $10 \text{ cm}^3/\text{cm}^2/\text{sec}$ .

8. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 1 wherein non-woven fabric of the segregating membrane supporting material includes polyacrylonitrile-based synthetic fibers and binder fibers.

9. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 8 wherein the binder fibers of the segregating membrane supporting material include a choice of

polyester fibers, polyolefin fibers, nylon fibers, aramide fibers, or polyphenylene sulfide fibers.

10 A laminated material of a segregating membrane and a segregating  
5 membrane supporting material as recited in claim 8 wherein the binder fibers of the segregating membrane supporting material are low melting point polyester fibers.

11. A laminated material of a segregating membrane and a  
10 segregating membrane supporting material as recited in claim 8 wherein the binder fibers of the segregating membrane supporting material are un-extended polyester fibers.

12. A laminated material of a segregating membrane and a  
15 segregating membrane supporting material as recited in claim 8 wherein the non-woven fabric of the segregating membrane supporting material includes 20 weight % to 90 weight % binder fibers.

13. A laminated material of a segregating membrane and a  
20 segregating membrane supporting material as recited in claim 1 wherein thickness of the segregating membrane supporting material made from thermo-compressed non-woven fabric is 50  $\mu\text{m}$  to 150  $\mu\text{m}$ .

14. A method of manufacturing a laminated material in which a  
25 segregating membrane is laminated on a segregating membrane supporting material wherein fibers are assembled in three-dimensions to form non-woven fabric, and non-woven fabric is processed by thermo-compression to join together fibers, which make up the non-woven fabric in sheet form, making the segregating membrane supporting material,

30 the step comprising of:

processing by thermo-compression of the non-woven fabric including at least 10 weight % polyacrylonitrile-based synthetic fibers having a fiber length of 1mm-25mm to make a segregating membrane supporting material

with overall bulk density 40% to 75% of the density of the fibers which make up the non-woven fabric,

manufacturing the segregating membrane supporting material wherein polyacrylonitrile-based synthetic fibers included in the non-woven fabric are  
5 dissoluble in amide-based solvents or in sulfoxide-based solvents as a mutual solvent for forming the segregating membrane, and

laminating the segregating membrane supporting material with the segregating membrane including at least a choice of polysulfone based, polyvinylidene fluoride-based, polyamide-based, polyimide-based, or  
10 polyacrylonitrile-based high polymer materials.

15. A method of manufacturing a laminated material as recited in claim 14 wherein the segregating membrane supporting material is made from non-woven fabric, including 10 weight % to 100 weight %  
15 polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

16. A method of manufacturing a laminated material as recited in claim 14 wherein the segregating membrane supporting material is made from non-woven fabric, including 20 weight % to 70 weight %  
20 polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

17. A method of manufacturing a laminated material as recited in claim 14 wherein the segregating membrane supporting material is made from non-woven fabric, including 30 weight % to 60 weight %  
25 polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

18. A method of manufacturing a laminated material as recited in claim 14 wherein the segregating membrane supporting material is made from non-woven fabric, including 40 weight % to 60 weight %  
30 polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

19. A method of manufacturing a laminated material as recited in claim 14 wherein the segregating membrane supporting material is formed by using polyacrylonitrile-based synthetic fibers of size of diameter of 3.5 to 49.6  $\mu\text{m}$ .

20. A method of manufacturing a laminated material as recited in claim 14 wherein the segregating membrane supporting material is made from non-woven fabric which is thermo-compressed to give a permeability of 0.5  $\text{cm}^3/\text{cm}^2/\text{sec}$  to 10  $\text{cm}^3/\text{cm}^2/\text{sec}$ .

21. A method of manufacturing a laminated material as recited in claim 14 wherein the segregating membrane supporting material is made by using non-woven fabric including polyacrylonitrile-based synthetic fibers and binder fibers.

22. A method of manufacturing a laminated material as recited in claim 21 wherein the segregating membrane supporting material is made by using a choice of polyester fibers, polyolefin fibers, nylon fibers, aramide fibers, or polyphenylene sulfide fibers as binder fibers.

23. A method of manufacturing a laminated material as recited in claim 21 wherein the segregating membrane supporting material is made by using low melting point polyester fibers as binder fibers.

24. A method of manufacturing a laminated material as recited in claim 21 wherein the segregating membrane supporting material is made by using un-extended polyester fibers as binder fibers.

25. A method of manufacturing a laminated material as recited in claim 21 wherein the segregating membrane supporting material includes 20 weight % to 90 weight % binder fibers.

26. A method of manufacturing a laminated material as recited in claim 14 wherein thickness of the segregating membrane supporting material made from thermo-compressed non-woven fabric is 50  $\mu\text{m}$  to 150  $\mu\text{m}$ .

5        27. A method of manufacturing a laminated material as recited in claim 14 wherein the segregating membrane supporting material is made from non-woven fabric which is transported through and sandwiched between two rollers for thermo-compression processing.

10       28. A method of manufacturing a laminated material as recited in claim 27 wherein one of the two rollers for thermo-compression processing is a heating roller to make the segregating membrane supporting material.

15       29. A method of manufacturing a laminated material as recited in claim 27 wherein thermo-compression processing is by two heating rollers to make the segregating membrane supporting material.

20       30. A method of manufacturing a laminated material as recited in claim 27 wherein the segregating membrane supporting material is made from non-woven fabric which is thermo-compressed by heating roller with a surface temperature of 200°C to 250°C.

25       31. A method of manufacturing a laminated material as recited in claim 27 wherein non-woven fabric is transported via heating roller at a speed of 20 m/min to 100 m/min.

32. A laminated material of a segregating membrane and a segregating membrane supporting material in which a segregating membrane is laminated on a segregating membrane supporting material comprising:

30       a segregating membrane including at least a choice of polysulfone-based, polyvinylidene fluoride-based, polyamide-based, polyimide-based, or polyacrylonitrile-based high polymer materials, and  
a segregating membrane supporting material wherein,

fibers are assembled in three-dimensions to form non-woven fabric,  
non-woven fabric is processed by thermo-compression to join  
together fibers, which make up the non-woven fabric in sheet form, making  
the segregating membrane supporting material, and

5 non-woven fabric including at least 10 weight %  
polyacrylonitrile-based synthetic fibers and low melting point polyester binder  
fibers is processed by thermo-compression making a segregating membrane  
supporting material with overall bulk density 40% to 75% of the density of the  
fibers which make up the non-woven fabric, and

10 wherein polyacrylonitrile-based synthetic fibers included in the  
non-woven fabric of the segregating membrane supporting material are  
dissoluble in amide-based solvents or in sulfoxide-based solvents as a mutual  
solvent for forming the segregating membrane.

15 33. A laminated material of a segregating membrane and a  
segregating membrane supporting material as recited in claim 32 wherein the  
segregating membrane supporting material is made from non-woven fabric,  
including 10 weight % to 100 weight % polyacrylonitrile-based synthetic fibers,  
which is thermo-compressed.

20 34. A laminated material of a segregating membrane and a  
segregating membrane supporting material as recited in claim 32 wherein the  
segregating membrane supporting material is made from non-woven fabric,  
including 20 weight % to 70 weight % polyacrylonitrile-based synthetic fibers,  
25 which is thermo-compressed.

30 35. A laminated material of a segregating membrane and a  
segregating membrane supporting material as recited in claim 32 wherein the  
segregating membrane supporting material is made from non-woven fabric,  
including 30 weight % to 60 weight % polyacrylonitrile-based synthetic fibers,  
which is thermo-compressed.

36. A laminated material of a segregating membrane and a  
segregating membrane supporting material as recited in claim 32 wherein the



segregating membrane supporting material is made from non-woven fabric, including 40 weight % to 60 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

5           37. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 32 wherein size of polyacrylonitrile-based synthetic fiber included in non-woven fabric of the segregating membrane supporting material is diameter of 3.5 to 49.6  $\mu\text{m}$ .

10           38. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 32 wherein length of polyacrylonitrile-based synthetic fiber included in non-woven fabric of the segregating membrane supporting material is 1mm to 25mm.

15           39. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 32 wherein permeability of the segregating membrane supporting material is 0.5  $\text{cm}^3/\text{cm}^2/\text{sec}$  to 10  $\text{cm}^3/\text{cm}^2/\text{sec}$ .

20           40. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 32 wherein the segregating membrane supporting material includes 20 weight % to 90 weight % binder fibers.

25           41. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 32 wherein thickness of the segregating membrane supporting material made from thermo-compressed non-woven fabric is 50  $\mu\text{m}$  to 150  $\mu\text{m}$ .

30           42. A laminated material of a segregating membrane and a segregating membrane supporting material in which the segregating membrane is laminated on the segregating membrane supporting material comprising:



a segregating membrane including at least a choice of polysulfone-based, polyvinylidene fluoride-based, polyamide-based, polyimide-based, or polyacrylonitrile-based high polymer materials, and

a segregating membrane supporting material wherein,

5 fibers are assembled in three-dimensions to form non-woven fabric, non-woven fabric is processed by thermo-compression to join together fibers, which make up the non-woven fabric in sheet form, making the segregating membrane supporting material, and

non-woven fabric including at least 10 weight %

10 polyacrylonitrile-based synthetic fibers and un-extended polyester binder fibers is processed by thermo-compression making a segregating membrane supporting material with overall bulk density 40% to 75% of the density of the fibers which make up the non-woven fabric, and

wherein polyacrylonitrile-based synthetic fibers included in the  
15 non-woven fabric of the segregating membrane supporting material are dissoluble in amide-based solvents or in sulfoxide-based solvents as a mutual solvent for forming the segregating membrane.

43. A laminated material of a segregating membrane and a  
20 segregating membrane supporting material as recited in claim 42 wherein the segregating membrane supporting material is made from non-woven fabric, including 10 weight % to 100 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

25 44. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 42 wherein the segregating membrane supporting material is made from non-woven fabric, including 20 weight % to 70 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

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45. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 42 wherein the segregating membrane supporting material is made from non-woven fabric,

including 30 weight % to 60 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

46. A laminated material of a segregating membrane and a  
5 segregating membrane supporting material as recited in claim 42 wherein the segregating membrane supporting material is made from non-woven fabric, including 40 weight % to 60 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

10 47. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 42 wherein size of polyacrylonitrile-based synthetic fiber of the segregating membrane supporting material is diameter of 3.5 to 49.6  $\mu\text{m}$ .

15 48. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 42 wherein length of polyacrylonitrile-based synthetic fiber of the segregating membrane supporting material is 1mm to 25mm.

20 49. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 42 wherein permeability of the segregating membrane supporting material is 0.5  $\text{cm}^3/\text{cm}^2/\text{sec}$  to 10  $\text{cm}^3/\text{cm}^2/\text{sec}$ .

25 50. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 42 wherein the segregating membrane supporting material includes 20 weight % to 90 weight % binder fibers.

30 51. A laminated material of a segregating membrane and a segregating membrane supporting material as recited in claim 42 wherein thickness of the segregating membrane supporting material made from thermo-compressed non-woven fabric is 50  $\mu\text{m}$  to 150  $\mu\text{m}$ .

52. A method of manufacturing a laminated material in which a segregating membrane is laminated on a segregating membrane supporting material wherein fibers are assembled in three-dimensions to form non-woven fabric, and non-woven fabric is processed by thermo-compression to join together fibers, which make up the non-woven fabric in sheet form, making the segregating membrane supporting material,

the step comprising of:

processing by thermo-compression of the non-woven fabric including at least 10 weight % polyacrylonitrile-based synthetic fibers and low melting point polyester binder fibers to make a segregating membrane supporting material with overall bulk density 40% to 75% of the density of the fibers which make up the non-woven fabric,

manufacturing the segregating membrane supporting material wherein polyacrylonitrile-based synthetic fibers included in the non-woven fabric are dissoluble in amide-based solvents or in sulfoxide-based solvents as a mutual solvent for forming the segregating membrane, and

laminating the segregating membrane supporting material with the segregating membrane including at least a choice of polysulfone based, polyvinylidene fluoride-based, polyamide-based, polyimide-based, or polyacrylonitrile-based high polymer materials.

53. A method of manufacturing a laminated material as recited in claim 52 wherein the segregating membrane supporting material is made from non-woven fabric, including 10 weight % to 100 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

54. A method of manufacturing a laminated material as recited in claim 52 wherein the segregating membrane supporting material is made from non-woven fabric, including 20 weight % to 70 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

55. A method of manufacturing a laminated material as recited in claim 52 wherein the segregating membrane supporting material is made from

non-woven fabric, including 30 weight % to 60 weight %  
polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

56. A method of manufacturing a laminated material as recited in claim  
5 52 wherein the segregating membrane supporting material is made from  
non-woven fabric, including 40 weight % to 60 weight %  
polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

57. A method of manufacturing a laminated material as recited in claim  
10 52 wherein the segregating membrane supporting material is made by using  
polyacrylonitrile-based synthetic fibers having a fiber size of diameter of 3.5 to  
49.6  $\mu\text{m}$ .

58. A method of manufacturing a laminated material as recited in claim  
15 52 wherein the segregating membrane supporting material is made by using  
polyacrylonitrile-based synthetic fibers having a fiber length of 1mm to 25mm.

59. A method of manufacturing a laminated material as recited in claim  
52 wherein the segregating membrane supporting material is  
20 thermo-compressed to give a permeability of  $0.5 \text{ cm}^3/\text{cm}^2/\text{sec}$  to  $10 \text{ cm}^3/\text{cm}^2/\text{sec}$ .

60. A method of manufacturing a laminated material as recited in claim  
52 wherein the segregating membrane supporting material includes 20  
25 weight % to 90 weight % binder fibers.

61. A method of manufacturing a laminated material as recited in claim  
52 wherein thickness of the segregating membrane supporting material made  
from thermo-compressed non-woven fabric is  $50 \mu\text{m}$  to  $150 \mu\text{m}$ .

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62. A method of manufacturing a laminated material as recited in claim  
52 wherein the segregating membrane supporting material is made from

non-woven fabric which is transported through and sandwiched between two rollers for thermo-compression processing.

63. A method of manufacturing a laminated material as recited in claim 5 62 wherein one of the two rollers for thermo-compression processing is a heating roller to make the segregating membrane supporting material.

64. A method of manufacturing a laminated material as recited in claim 62 wherein thermo-compression processing is by two heating rollers to make 10 the segregating membrane supporting material.

65. A method of manufacturing a laminated material as recited in claim 62 wherein the segregating membrane supporting material is made from non-woven fabric which is thermo-compressed by heating roller with a surface 15 temperature of 200°C to 250°C.

66. A method of manufacturing a laminated material as recited in claim 62 wherein non-woven fabric is transported via heating roller at a speed of 20 m/min to 100 m/min.

20 67. A method of manufacturing a laminated material in which a segregating membrane is laminated on a segregating membrane supporting material wherein fibers are assembled in three-dimensions to form non-woven fabric, and non-woven fabric is processed by thermo-compression to join 25 together fibers, which make up the non-woven fabric in sheet form, making the segregating membrane supporting material,

the step comprising of:

processing by thermo-compression of the non-woven fabric including at least 10 weight % polyacrylonitrile-based synthetic fibers and un-extended 30 polyester binder fibers to make a segregating membrane supporting material with overall bulk density 40% to 75% of the density of the fibers which make up the non-woven fabric,

manufacturing the segregating membrane supporting material wherein polyacrylonitrile-based synthetic fibers included in the non-woven fabric are dissoluble in amide-based solvents or in sulfoxide-based solvents as a mutual solvent for forming the segregating membrane, and

5 laminating the segregating membrane supporting material with the segregating membrane including at least a choice of polysulfone based, polyvinylidene fluoride-based, polyamide-based, polyimide-based, or polyacrylonitrile-based high polymer materials.

10 68. A method of manufacturing a laminated material as recited in claim 67 wherein the segregating membrane supporting material is made from non-woven fabric, including 10 weight % to 100 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

15 69. A method of manufacturing a laminated material as recited in claim 67 wherein the segregating membrane supporting material is made from non-woven fabric, including 20 weight % to 70 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

20 70. A method of manufacturing a laminated material as recited in claim 67 wherein the segregating membrane supporting material is made from non-woven fabric, including 30 weight % to 60 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

25 71. A method of manufacturing a laminated material as recited in claim 67 wherein the segregating membrane supporting material is made from non-woven fabric, including 40 weight % to 60 weight % polyacrylonitrile-based synthetic fibers, which is thermo-compressed.

30 72. A method of manufacturing a laminated material as recited in claim 67 wherein the segregating membrane supporting material is made by using polyacrylonitrile-based synthetic fibers having a fiber size of diameter of 3.5 to 49.6  $\mu\text{m}$ .

73. A method of manufacturing a laminated material as recited in claim 67 wherein the segregating membrane supporting material is made by using polyacrylonitrile-based synthetic fibers having a fiber length of 1mm to 25mm.

74. A method of manufacturing a laminated material as recited in claim 67 wherein the segregating membrane supporting material is thermo-compressed to give a permeability of  $0.5 \text{ cm}^3/\text{cm}^2/\text{sec}$  to  $10 \text{ cm}^3/\text{cm}^2/\text{sec}$ .

75. A method of manufacturing a laminated material as recited in claim 67 wherein the segregating membrane supporting material includes 20 weight % to 90 weight % binder fibers.

76. A method of manufacturing a laminated material as recited in claim 67 wherein thickness of the segregating membrane supporting material made from thermo-compressed non-woven fabric is  $50 \mu\text{m}$  to  $150 \mu\text{m}$ .

77. A method of manufacturing a laminated material as recited in claim 67 wherein the segregating membrane supporting material is made from non-woven fabric which is transported through and sandwiched between two rollers for thermo-compression processing.

78. A method of manufacturing a laminated material as recited in claim 77 wherein one of the two rollers for thermo-compression processing is a heating roller to make the segregating membrane supporting material.

79. A method of manufacturing a laminated material as recited in claim 77 wherein thermo-compression processing is by two heating rollers to make the segregating membrane supporting material.

80. A method of manufacturing a laminated material as recited in claim 77 wherein the segregating membrane supporting material is made from



non-woven fabric which is thermo-compressed by heating roller with a surface temperature of 200°C to 250°C.

81. A method of manufacturing a laminated material as recited in claim  
5 77 wherein non-woven fabric is transported via heating roller at a speed of 20 m/min to 100 m/min.